An Empirical Analysis of Paper Selection by Digital Printers

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An Empirical Analysis of Paper Selection by Digital Printers

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I would like to dedicate this work to my family for their support, patience and strong belief in me. Without their continuous encouragement I would have never had the power to make the decisions that have made my life so enjoyable and this work possible.

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SUMMARY

The Printing Industry is undergoing a “Digital Revolution”. The importance of digital printing has been increasing substantially over the last decade. How has this development affected the paper selection of printing firms? Only paper suppliers who successfully anticipate the changing needs of the printing firms will be able to benefit from the industry trend.

This paper employs a probability model to analyze a survey data set of 103 digital printing firms in the USA and Canada. The research idea is to link the firm’s paper selection with the firm’s characteristics in order to gain insights into the printing firm’s paper purchase behavior and the overall industry structure.

The first part of this work investigates the importance of certain paper aspects, such as price, runnability and print quality. Strikingly, a company’s involvement in digital printing, measured by the percent of digital printers of the total number of printers in the firm, is a central determinant of the importance of all paper aspects analyzed. This finding underscores the tremendous importance of the printing firms’ transition to digital printing for the Paper Industry. Paper runnability is found to become more important the faster the firm grows and can be explained by the fact that more successful firms incur higher opportunity costs from downtime. Another key finding is that the importance of paper price is lower for firms who collaborate with their customer on the paper selection and are able to pass on cost increases in the paper price.

The second part involves a more direct assessment of paper selection. Here, the firm's characteristics are utilized to explain the choice of coated versus uncoated paper for the printing job. The analysis shows that firms involved in sophisticated print services, such as Digital Asset Management or Variable Data Printing are more likely to use the high quality coated paper. Further it is found that the usage of coated paper increases with catalog printing whereas it decreases with book and manual printing.

INTRODUCTION

The Printing Industry is increasing the usage of high-tech digital printers. The first digital presses hit the market in 1995. At that time, constraints such as unreliable runnability and a limited availability of paper compatible with the new technologies prevented digital printing from capturing a considerable market share. Today, as printing firms start to appreciate the technological improvements of digital printing and paper manufacturers produce paper geared towards the needs of a digital press, the importance of digital jobs in the printing industry is growing. In the NAPL 2006 State of the Industry Survey, 57% of the participants expected the digital printing segment to grow fastest among all services offered by printing firms. This shows that the production share, and with it, the importance of digital printing will be growing in the years to come.

This trend has obvious consequences for the Paper Industry as the supplier of the Printing Industry. In order to maximize future profit it is essential for paper producers to create new products by anticipating the changes in the structure of printing business. In particular it is vital to understand the technical requirements for paper used in digital printing and factors influencing the printing firms' decision on which paper to buy.

This study aims at understanding the paper purchase decision of digital printing firms by using a sample of US and Canadian printing companies. The idea is to link the paper purchase decision with the characteristics of the firms. That is, use a firm's characteristics to predict its paper selection.

The first part, explores aspects of the paper selection emphasized by firms with a certain set of characteristics. This information is of potential interest to paper producers as it enables them to tailor their marketing efforts more accurately towards their customers.

In the second part, the firm's characteristics are utilized to predict the firm's paper grade selection. In particular the choice between coated and uncoated paper grades is analyzed.

PART I: IMPORTANCE FACTORS AS INDICATORS OF FIRM'S PAPER SELECTION

CHAPTER 2: Introduction Part I

The first part of the paper is dedicated to analyzing different importance factors provided in the data set. [Figure 1] gives an overview of all importance factors ranked in the survey. The importance of runnability has been ranked very high by almost all respondents.

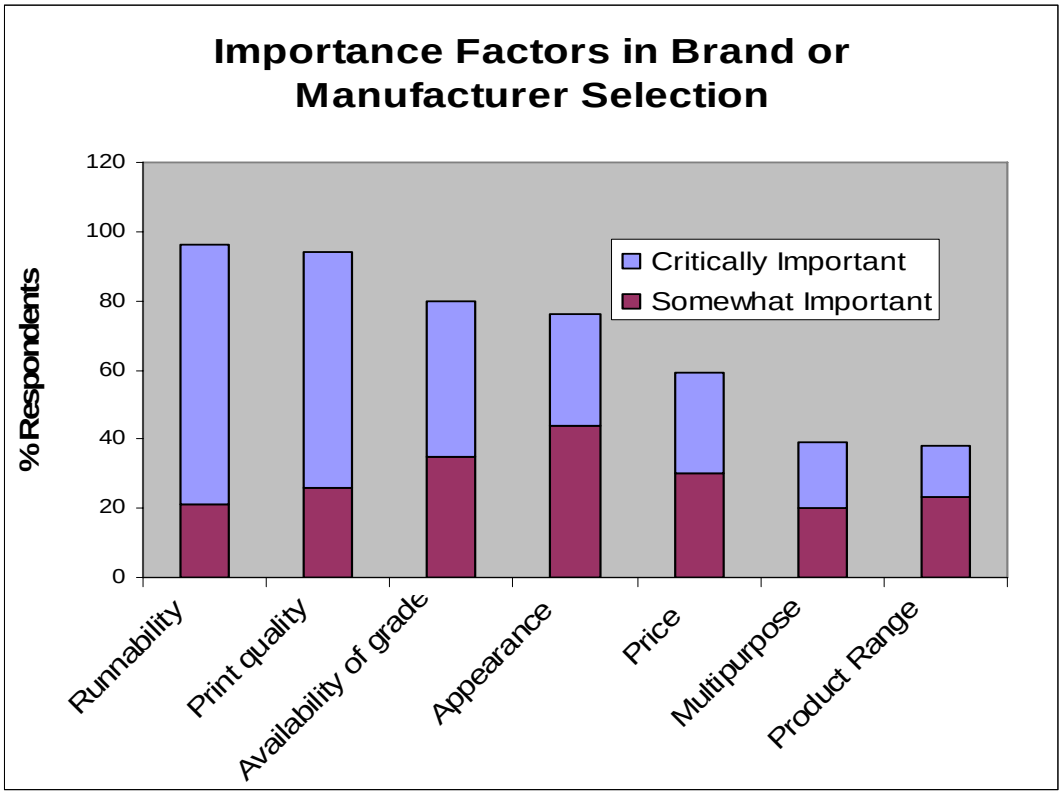

Figure 1: Importance Factors

This is not very surprising since paper runnability plays a key role in company's quality control. Poor runnability generates two problems: First, a paper jam in large scale printing jobs causes significant disruption in printing, ink spillover, possible warping and

sometimes formatting problems with affected pages or even the ones after the affected pages. This type of cost will be referred to as material cost. Second, paper jams create a time cost of fixing the printing machine. In practice, companies constructing printing machines often times assess the runnability of different paper brands and based on the results issue recommendations as to which paper functions best with their high speed digital presses.[1]

On the contrary the importance of price was ranked relatively low compared to the other importance factors. This is remarkable, as the paper price is a direct driver of the unit cost for printing firms.

Runnability and price showed the most unique results and are therefore emphasized in the importance factors analysis. The importance of quality also receives considerable attention since knowledge about which kind of firms emphasize price or quality will provide insights into the overall industry structure.

[1] See Dewitz (2004), p. 12

CHAPTER 3: Data

3.1. Source

The study is based on a survey data set provided by the Printing Industry Center at Rochester Institute of Technology. The telephone survey was conducted in 2005 and is comprised of 103 printing firms in the USA and Canada. All of the companies are involved in digital printing of some sort. Most companies in the survey however, provide non-digital printing services as well. The extensive survey can be organized into the following categories:

- Company demographics
- Specifics about companies' employees
- Paper grades used in the printing process
- Importance of parameters and characteristics in the purchase decision
- Limitations imposed by printing presses
- Trends in paper prices

Evans and LeMaire (2005) provide a detailed evaluation of the survey results, where the main emphasis is put on a descriptive analysis of the data. Their results constitute the basis for the econometric analysis undertaken in this work.

3.2. Setup and descriptive statistics

3.2.1. Variable Setup

The firm's characteristics are used as explanatory variables in the econometric models. [Table 1] gives an overview of the characteristics extracted from the data set and used in the analysis. The explanatory variables are divided into seven sets.

1. The first set constitutes the firm's demographics and includes the number of employees, the growth of the number of employees over the last five years, as well as the revenue and revenue growth over the last year.
2. The second set comprises the printing firm's involvement in different areas of business. The printing firms report their involvement in a certain business area on a scale from 0 to 3 where 0 means that the firm never performs this kind of job and 3 means that the job constitutes a major part of the firm's job.
3. The third set reflects the percentage of digital printers of the overall number of printers used in the firm (the overall number is made up of digital and non-digital printers). A number of firms did not provide data on the quantity of digital and/or non-digital presses. In order to include these firms in the estimation a dummy variable was created, which is 1, for firms that provided insufficient information to compute the percentage of digital printers.
4. The fourth set is made up of three dummy variables. *DAM* and *VDP* reflect whether the firm performs Digital Asset Management and Variable Data Printing respectively. *Digital_asset_train* is a dummy variable with value one if the firm's employees are trained for Digital Asset Database setup and handling.
5. The fifth set consists of dummy variables indicating whether the firm owns at least one HP Indigo, Xerox or Canon printer respectively.

Table 1: Firm Characteristics

Firm		Explanation
Employees		Number of employees divided by 100
Employee Growth		Employee growth over the last 5 years
Revenue		Revenue generated in 2004
Revenue Growth		Revenue growth compared to last year
Marketing	Printing Job Performed	Marketing and promotional materials
Manuals		Manuals and documents
Direct Mail		Direct mail
Quick Print		Quick printing applications
Business		Business communications
Catalogs		Catalogs and directories
Magazines		Magazines and periodicals
Trans		Transactional / financial forms or documents
Book		Book production
Signage		Signage
Labels		Labels and wrappers
Dig. Printer %		(#digital presses) / (#digital presses + #non-digital presses)
Dig. Printer N/A		Information for % of digital presses not available for this firm
HP Indigo		Firm uses at least one HP Indigo
Xerox		Firm uses at least one kind of Xerox press
Canon		Firm uses at least one kind of Canon press
DAM		Firm has established a business in Digital Asset Management
VDP		Firm has established a business in Variable Data Printing
Dig. Asset Train		Employees trained in Digital Asset Database setup and handling
Portfolio size		Portfolio size on a scale from 1 to 4
Together		Printing firm and customer together decide over paper brand
Alone customer		The customer alone decides which paper brand to purchase
Cut		Size, cut size
Coating		Press limitation: Paper must be pre-coated
Weight		Has to be under a particular weight
None		The digital presses do not impose any restrictions on the paper
Pass on %[2]		Percent of cost increases passed on to customers
Pass on N/A		Pass on information is not available

[2] The variables describing the ability of a firm to pass on cost to the customers will be introduced in section 5.1.3.

6. The sixth set of variables captures the paper selection procedure in the firm.
    - The variable Portfolio represents the number of paper brands in the purchasing portfolio of the firm, reported on a scale from 1 to 4. If the firm has one brand in the portfolio the variable takes on a value of 1, up to five brands a value of 2, from six to ten brands a value of 3 and for greater than ten brands a value of 4.[3]
    - The dummy variable *Together* indicates the paper selection decision is made in collaboration with the customer.
    - The dummy variable *Alone_customer* indicates the paper selection decision is made by the customer only.
7. The final set of variables shows whether the presses pose any restrictions on the firm's paper purchase decision. If the presses used by the firm require a certain cut of the paper the dummy *Cut* takes on the value 1. In case the firm can only use pre-coated paper the dummy variable *Coating* takes on the value of 1. Requirements on the paper weight are captured by the dummy *Weight*. In case the firm has no limitations on the use of paper the dummy variable *None* takes on the value of 1.

The variables describing the ability of a firm to pass on cost to the customers will be introduced in section 5.1.3.

[3] "Paper brand" is defined as a manufacturer such as International Paper. However, some respondents interpreted "brand" as a specific paper grade. Obvious outliers were removed from the data set. Utilizing a scale from 1 to 4 further reduces the impact of the remaining firms that misinterpreted the term.

3.2.2. Summary Statistics of Variables

The data set used in the analysis includes 93 companies. Ten companies were deleted from the data set due to missing values. [Table 2] provides descriptive statistics for the variables introduced in [Table 1]. The statistics were computed for the remaining set of 93 companies.

Employees is defined as the number of employees divided by 100. The average company in the sample has 82 employees where the smallest company has only 1 employee and the largest company has 2500 employees.

A firm's employee growth in the sample ranges from -77% to 233% and the average firms' number of employees grew at a rate of 13.5% over the last five years.
The average firms' revenue lies between category 1 and 2 on a scale from 1 to 6 where 1 represents a revenue of less than $3 million, 2 represents a revenue of up to $5 million and 6 represents more than $20 million.

Revenue_growth is a variable representing growth over the last 12 months. The growth of revenue takes a value of 1 if the company's revenue decreased, a value of 2 if it remained stable and a value of 3 if the revenue increased. The average value of the variable is 2.5, reflecting growth across the firms.

The firms' average marketing involvement ranks highest with a value of 2.5 on a scale from 0 to 3 and the firms' magazine printing ranks lowest. Quick print receives the second highest rank after marketing.

The variable *Dig_printer_perc* indicates the percent of the firms' printers that are digital printers. On average 43% of the printers in the firms sampled, are digital printers. However, 4.3% of the respondents did not provide enough information to compute the percentage of digital printers.

Table 2: Summary Statistics

Variable	Mean	Std Dev	Minimum	Maximum
Employees	0.82	2.78	0.01	25.00
Employee_growth	0.13	0.57	-0.77	2.30
Revenue	1.80	1.35	0.00	6.00
Revenue_growth	2.53	0.69	1.00	3.00
PJ_marketing	2.53	0.70	0.00	3.00
PJ_manuals	2.15	0.90	0.00	3.00
PJ_directmail	2.24	0.93	0.00	3.00
PJ_quickprint	2.29	0.97	0.00	3.00
PJ_buscom	2.15	0.90	0.00	3.00
PJ_catalogs	1.67	0.79	0.00	3.00
PJ_magazines	0.93	0.98	0.00	3.00
PJ_trans	1.26	1.04	0.00	3.00
PJ_book	1.41	1.14	0.00	3.00
PJ_signage	1.38	1.07	0.00	3.00
PJ_labels	1.45	0.94	0.00	3.00
Dig_printer_perc	0.44	0.33	0.00	1.00
Dig_printer_na	0.04	0.20	0.00	1.00
HP_indigo	0.22	0.41	0.00	1.00
Xerox	0.32	0.47	0.00	1.00
Canon	0.17	0.38	0.00	1.00
DAM	0.27	0.45	0.00	1.00
VDP	0.50	0.50	0.00	1.00
Digital_asset_train	0.50	0.50	0.00	1.00
Portfolio	2.19	1.06	1.00	4.00
Together	0.47	0.50	0.00	1.00
Alone_customer	0.20	0.41	0.00	1.00
Cut	0.18	0.39	0.00	1.00
Coating	0.11	0.31	0.00	1.00
Weight	0.29	0.46	0.00	1.00
None	0.17	0.38	0.00	1.00
Passon_perc	36	44	0.00	100.00
Passon_na	0.24	0.43	0.00	1.00

The variables *HP_Indigo*, *Xerox* and *Canon* indicate whether the firm owns at least one printer of that kind. Of the respondents, 21.5% use at least one HP Indigo, 32.3% use at least one Xerox, and 17.2% use at least one Canon. [4]

The average value of the variable *Portfolio* is 2.19 on a scale from 1 to 4. The average firm uses more than one paper brand, which is in line with Evans and LeMaire (2005), who report a median of five brands.

There is a strong tendency for firms (47.3% in the sample) to collaborate with their customers on the paper purchase decision. Only 20.4% solely rely on the customer to make the paper purchase decision.

In 17.2% of the firms no restrictions were placed on paper choice, 18.3% require specific cut or cut size, 10.8% require pre-coated paper and about 33% of the sample have some weight limitation on the paper.

[4] The Digital Printing firms use a large number of different brands and models of digital printers. HP_Indigo, Xerox and Canon were the only presses substantially represented in the data set.

CHAPTER 4: Methodology

4.1. Research Approach

This work attempts to understand the paper purchase decision of digital printing firms using statistical methods. An underlying idea is to link firms' paper purchase decisions to their characteristics. This will shed light on aspects of the paper selection emphasized by the printing companies surveyed.

In order to achieve this goal, the paper purchase decision is decomposed into different aspects and those aspects are then analyzed separately. The importance of price and the importance of runnability in the paper purchase decision will be central in this analysis. As noted earlier, the motivation to look at these two aspects in particular comes from Evans and LeMaire (2005) who find respondents emphasize the importance of runnability while, surprisingly, the factor price does not seem to play a key role in the purchase decision. [5]

[Figure 2] illustrates the way the firm's characteristics have been linked with its paper purchase decision. An econometric model is utilized to estimate the probability of a firm's ranking for each aspect based on the firm's characteristics. For example, the model uses the firm's characteristics to estimate the probability of it ranking importance of runnability as critically important.

[5] See [Figure 1]

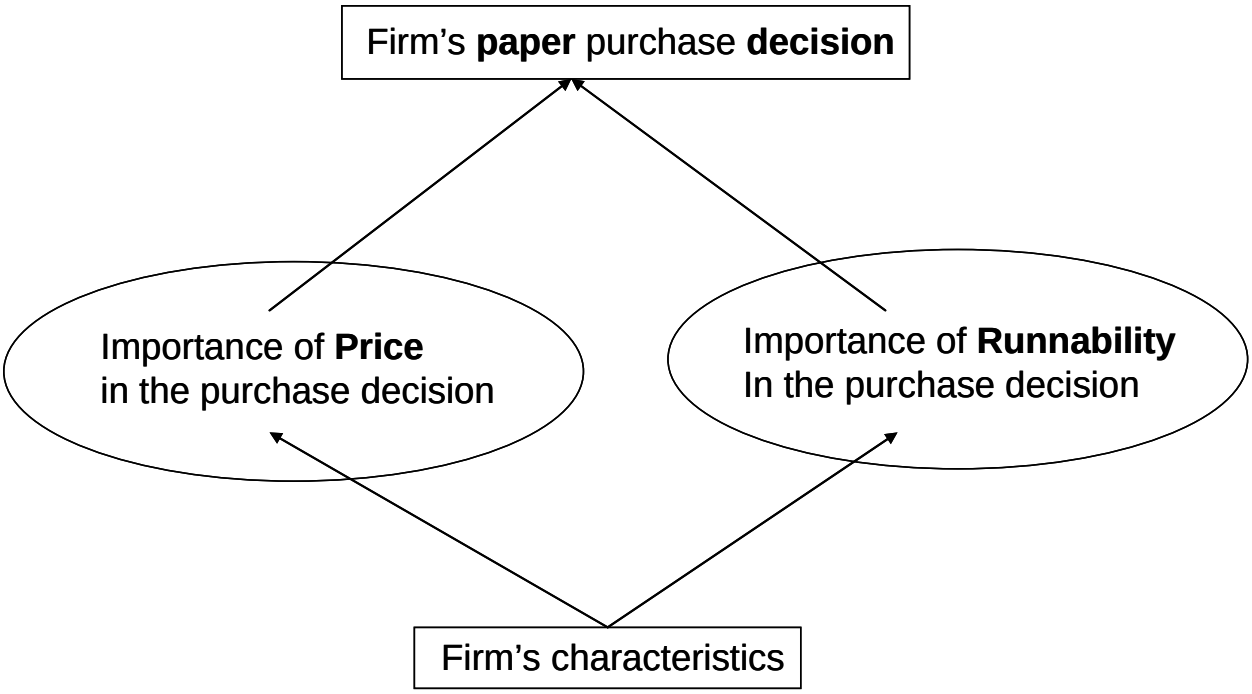

Figure 2: Research Approach

4.2. Econometric Model

The discrete nature of the data obtained by the telephone survey makes the use of a standard linear regression model inappropriate. A discrete dependent variable creates numerous problems in an Ordinary Least Squares regression. Thus, an analysis of the data requires the use of an alternative model. The two most commonly used frameworks are the Logit and Probit. The main difference between the two is the assumption on the distribution of the error term. The Logit model assumes a logistic distribution while the Probit model assumes a normal distribution. It can be shown, however, that the coefficients estimated by the two models will have the same sign.

The Logit model can be derived in different ways. In general any function that maps $\mathbf{x}\boldsymbol{\beta}$ into the range [0,1] can be used as a probability model. Aldrich and Nelson (1984) derive the Logit model starting with the odds of an event happening then equating

the log of the odds to $\mathbf{x}\boldsymbol{\beta}$.[6] A different approach to derive the Logit model is to assume an underlying latent variable (y*) that generates the observed discrete values of the dependent variable. This approach has the advantage that the estimated coefficients can be interpreted as the marginal effects on y*.

The probability model chosen for this project is the Ordered Logit model. The large majority of survey questions, that are potential dependent variables in the analysis, ask the respondent to rank a certain paper characteristic on a scale from 1 to 5 for example. Thus, the way the questions are asked imposes a natural ordering on the dependent variables. The alternative Multinomial Logit, usually used to model situations where no ordering is present, is necessary only if the Parallel Regression Assumption is rejected.

The survey questions ask respondents to rank the importance factor on an arbitrary ordinal scale. The importance of price however, can be thought of as a continuum not accurately captured by an ordinal scale. Thus, assuming an underlying latent variable y* is reasonable.

The decision for utilizing the Logit as opposed to the Probit model is the convenience of interpreting the results using the odd ratios.

The probability of a respondent *i* choosing an answer *m* is

$$\Pr(y_i = m \mid \mathbf{x}_i) = F(\tau_m - \mathbf{x}_i\boldsymbol{\beta}) - F(\tau_{m-1} - \mathbf{x}_i\boldsymbol{\beta}),$$

where $\mathbf{x}_i$ is a vector of the respondent's characteristics, $\boldsymbol{\beta}$ is a vector of the estimated coefficients, τ_m is the estimated cutoff for answer choice *m*. The symbol F represents the cumulative distribution function for the standard logistic distribution. [7,8]

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[6] $\mathbf{x}$ is a matrix representing the respondents' characteristics and $\boldsymbol{\beta}$ is a vector of the estimated coefficients

[7] $F(z) = \dfrac{\exp(z)}{1+\exp(z)}$

[8] For a detailed treatment of the Logit model see Long (1997)

CHAPTER 5: Results

5.1. The Importance of Price

The price sensitivity of demand is of central interest in economics and consequently of high interest in this study of the printing industry. To determine which firms strongly weighed the price of paper in their paper selection is a key part of this paper. It is important to bear in mind that the price in question is the input price of the printing firms and not the price of the final products (the printed documents). Still an analysis of the input price can yield vital insights into the structure of the industry.

5.1.1. Expected Signs

The expected sign for the variables *Revenue* and *Employees* is negative, because in general, larger firms were expected to be less price sensitive. There are several arguments for this assumption. First, larger firms tend to be financially stronger. Second, more established firms have built an image that binds customers over time. Third, larger firms are able to spend more money on marketing. Thus, bigger firms are more renowned in the market enabling them to charge more. Thus for these firms, a higher input price does not automatically imply a smaller markup as they may be able to compensate the cost increase by charging higher prices.

The company's growth, represented by the two variables *Employee_growth* and *Revenue_growth*, could have a positive or negative effect on price sensitivity. On the one hand, faster growing firms might still be small and not able to charge customers a high price and at the same time require a high markup to feed the company's growth. On the other hand the fast growth of these firms could be an indication of their profitability. Highly successful firms are less price sensitive as their existence is not endangered by a

slight increase in paper price. Therefore, the sign of the growth variables is undetermined a priori.

The set of variables representing the sort of printing jobs the company performs is assumed to have high importance in explaining the weight a firm puts on the input price. The expected signs depend on the particularities of these printing.

It can be argued that the printing industry is undergoing a transition from non-digital to more digital printing in recent years. The variable *Dig_printer_perc* can be interpreted as a measure of the progress towards digital printing of a firm. It is expected that companies performing mainly digital printing care less about the input price and more about other paper characteristics like quality and runnability. The reason is that the complexity of digital printers forces firms to purchase paper of a certain minimum standard. Therefore the expected sign the variable is negative.

Similar to the percent of digital printers, the variables *DAM*, *VDP* and *Digital_asset_train* indicate more advanced techniques and quality products. The firms operating in these segments of the market are expected to care less about the input price and more about quality characteristics of the paper.

Companies with a larger portfolio of paper suppliers are expected to be more sensitive to price. It is assumed that the reason for their maintaining this large portfolio is the ability to substitute quickly in case price increases for one brand. Firms that make the purchase decision together with their customer are assumed to place less weight on the input price. The assumption is that by communicating the cost increases to the customer, the firm is able to pass on some of theses costs.

5.1.2. Main Estimation Results

As described earlier the final data set comprised 93 printing companies. The companies ranked the importance of price on a scale from 1 to 5 where 1 is the lowest importance. Due to the low number of companies in categories 1 and 2, both were collapsed into category 3. [Table 3] shows the distribution of these 93 companies across

categories 3 to 5. The firms are distributed evenly across the categories. This promotes model fit in a situation where the total number of observations is relatively low.

Table 3: Estimation Results for the Importance of Price regression

Ordered Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept 2	0.376	0.976	0.6998	
Intercept 1	1.907	0.997	0.0558	
Revenue	-0.345	0.174	0.0479	0.708
Employee_growth	-0.179	0.379	0.6375	0.836
PJ_marketing	-0.556	0.294	0.0585	0.574
PJ_catalogs	0.654	0.287	0.0228	1.922
Together	-1.075	0.433	0.0129	0.341
Score Test		3.8984[9]		0.5641
Log-likelihood at mean		-101.3		
Log-likelihood at convergence		- 91.9		
Frequency in category				
Price_imp=5	27			
Price_imp=4	29			
Price_imp=3	37			

The final model was obtained by running the full model and then eliminating insignificant variables. [Table 3] shows the estimation results and that the overall model fit is good. The likelihood ratio test rejects the null hypothesis that all the coefficients are equal to zero, with a p-value of 0.0022. As mentioned above, an inherent property of the Ordinary Logit model is the Parallel Regression Assumption. Therefore, an important justification for using the Ordered Logit as opposed to a multinomial model is that the coefficients are equal (or at least similar) across categories. One test assessing this important assumption is the Score Test. The test yields a p-value of 0.56 indicating that

[9] This is a chi square statistic.

the Parallel Regression Assumption cannot be rejected and that the coefficients can be considered similar across categories.

When interpreting the coefficients it is important to keep in mind that this is a nonlinear model. The coefficients do not represent the marginal effects on the probability of higher price sensitivity. By taking the exponential value of the coefficients we obtain the change in the odd-ratio.

The sign of *Revenue* turns out as expected. Thus, the higher the company's revenue, the lower the probability of that firm highly weighing the importance of price in the paper purchase decision. The variable is statistically significant at the 95% confidence level.

The variable *Employee_growth* also has a negative coefficient and implies that a faster growing company puts less weight on paper price. The variable was included in the model although it is statistically insignificant (p-value 0.63). The estimated sign still yields some information and can be contrasted with the results of the runnability model.

Companies that print marketing materials put less emphasis on the price. The following section explains why firms that print marketing materials actually care more about runnability. This suggests that while overall costs play an important role, companies are willing to purchase relatively more costly paper if this paper proves to have high runnability and reduce the actual production cost. On the contrary, if a company prints catalogs, the company is likely to put higher weight on price. The coefficient is statistically significant at a 95% confidence level.

The variable *Together* shows the highest estimated coefficient and therefore has the strongest effect on the probability of price importance. If a firm collaborates with customers on the paper purchase decision, the likelihood of placing high weight on the price of paper decreases. A firm that communicates cost increases to the customer might be able to pass on cost increases in paper more easily.

Although these findings were expected, they required further elaboration. Fortunately the data set included information on the firm's ability to pass on cost increases to the customer and explain a firm's price sensitivity. However, a large number of firms did not reveal their ability to pass on cost increases to the consumer. Given the relatively small number of firms in the data set an elimination of these firms was

impossible if reasonable results were to be obtained. Consequently, to overcome this problem the following method was utilized. A dummy variable was created, taking on the value 1 if the firm did not reveal its ability to pass on cost increases to the customer. The following section discusses the results in detail.

5.1.3. Further Results (Cost pass on)

[Table 2] provides the descriptive statistics for the variables used to determine the relationship between price sensitivity and the ability of firms to pass on cost. The variable *Passon_perc* represents the percent of a paper's cost increase that a company is able to pass on. In case the company did not reveal this information the variable is set to 0 and the variable Passon_na takes on the value 1.

Including these two additional explanatory variables in the preceding regression does not yield significant coefficients for the variables at the 90% confidence level.[10] At least part of the reason for the insignificance is the positive correlation between the variables *Together* and *Passon_perc* (5.82%). In order to highlight the importance of a firm's ability to pass on cost increases to customers when ranking paper price importance, a separate model was estimated regressing *Price_imp* on *Passon_perc* and *Passon_na*. [Table 4] shows the results for the price importance explained by the pass on behavior of the firm. The overall model fit is quite good with a likelihood ratio test of all coefficients zero yielding a p-value of 0.1033.

The coefficient for *Passon_perc* is negative, indicating that firms which are able to pass on cost increases in paper price to customers are less likely to highly emphasize price. This result is very intuitive. If a firm does not have to bear the full effect of a paper cost increase then the parameter price will lose importance in the paper purchase decision of that firm. The coefficient is statistically significant at the 90% confidence level.

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[10] *Passon_perc* has a coefficient of -0.6855 with a p-value of 0.1978. *Passon_na* shows a coefficient of -0.8008 with a p-value of 0.1463. Note that the signs of the coefficients match with those estimated in the separate model reported in [Table 4].

Interestingly the dummy variable *Passon_na* turns out to be significant, both economically and statistically. Additionally the sign turns out to be negative. A possible interpretation is that those companies who do not reveal their pass on ability belong to those companies that are able to pass on a high percentage of their cost increases.

Table 4: Estimation Results: Price Importance related to pass on ability

Ordered Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept 5	-0.388	0.332	0.2436	
Intercept 4	0.974	0.347	0.0050	
Passon_perc	-0.826	0.501	0.0992	0.438
Passon_na	-1.013	0.520	0.0515	0.363
Score Test		0.1128	0.9452	
Log-likelihood at mean		-101.3		
Log-likelihood at convergence		- 99.0		
Frequency in category				
Price_imp=5	27			
Price_imp=4	29			
Price_imp=3	37			

This result supports the initial interpretation of the coefficient of the variable *Together*, given in the previous section. Firms that make their paper purchase decision together with the customer are able to communicate the increase to the customer and then pass parts (or all) of the cost increase to the customer. Firms that make the decision together with the customer, consequently, care less about the paper price as they do not have to suffer the full amount of cost increase.

5.1.4. Effects on predicted probability

In order to explore the impacts of the estimated variables on the probability of ranking price importance as low (category 3), medium (category 4) or high (category 5), the marginal effects and effects of discrete changes in independent variables were calculated and reported in [Table 5].

Table 5: Effects on *Price_imp*

Category 3			
Variable	Discrete	Marginal Effect	Quasi-Elasticity
Revenue	0.080		
Employee_growth		0.039	0.005
PJ_marketing	0.131		
PJ_catalogs	-0.124		
Together	0.260		
Category 4			
Variable	Discrete	Marginal Effect	Quasi-Elasticity
Revenue	-0.011		
Employee_growth		-0.008	<0.001
PJ_marketing	-0.026		
PJ_catalogs	-0.029		
Together	-0.083		
Category 5			
Variable	Discrete	Marginal Effect	Quasi-Elasticity
Revenue	-0.069		
Employee_growth		-0.038	-0.005
PJ_marketing	-0.105		
PJ_catalogs	0.154		
Together	-0.178		

Marginal effect and quasi-elasticity were calculated for continuous variables. Discrete variables were changed by one unit observing the effect on probability. Due to the nonlinear nature of the Logit model the amount of change, the level of the analyzed variable and the level of all other variables have to be taken into account when

calculating the above measures. Discrete variables were averaged and rounded to the nearest integer value.

Revenue was set to a value of 2 corresponding to a revenue level between $3 million and $5 million, *Employee_growth* was set to its mean value (0.13). *PJ_marketing* was set to a value of 2, while *PJ_catalogs* was set to 1 due to the lower average value. Finally, the dummy variable *Together* was assigned a value of 0.

If a company's revenue increases, such that it exceeds $5 million but is less than $10 million, the predicted probability of ranking price importance as low increases by about 0.08, "drawing" probability mainly from category 5 but also from category 4. The effect of revenue on the predicted probabilities is further explored using a graph. It is important to remember that the effects across categories must balance out such that the sum of the effects equals zero. [Figure 3] plots the predicted probability for each category as a function of the variable *Revenue*.

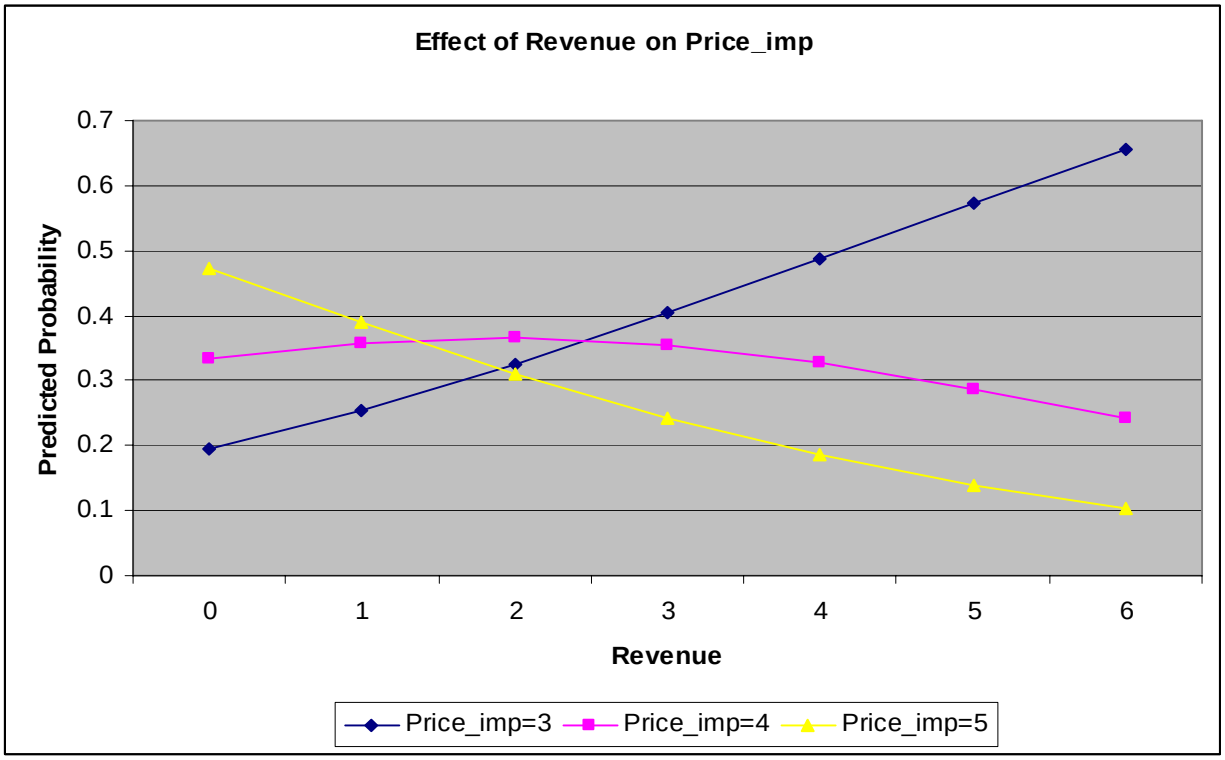

Figure 3: Pred. prob. of *Price_imp*=m for different levels of *Revenue*

The graph illustrates that the effect on category 4 depends on the value of *Revenue*. Up to revenue $5 million the effect is positive, whereas for larger revenues the effect is negative.

The impact of a one percent change in *Employee_growth* on the predicted probability is fairly small, thus increasing the probability of ranking price importance as low by 0.005 and decreasing the probability of ranking price importance as high by the same amount. If a company increases its involvement in printing marketing materials to "very frequently" the probability of ranking price as low increases by 0.131 and the probability of ranking price importance as high decreases by 0.105.

Changing the variable *PJ_catalogs* by one unit increases the predicted probability, by 0.154, of ranking price high. The effect on category 4 is unknown unless explicitly computed. In this case, category 4 loses slightly by -0.029, whereas most probability is drawn from category 3.

The dummy variable *Together* has the strongest effect on predicted probability. In case the paper purchase decision is made solely by the customer the probability of ranking the price importance as low increases by 0.26.

5.2. The Importance of Runnability

"Runnability is generally understood to encompass the performance of papers in press operation, such that sheets will run smoothly through the print engine without jamming, and webs will not break."[11] Oittinen and Saarelma (1998) define a measure for "good" runnability as: "The number of copies of acceptable quality produced in unit time." Therefore runnability is a measure of the efficiency in the production process and one factor in determining the unit cost of the product.

While both price and runnability of paper affect the production cost. The fact that almost all the respondents ranked runnability as an important factor in the paper purchase decision while only about 60% ranked price as such, suggests that overall runnability has a much stronger impact on the production cost of a firm. Further it is interesting to observe that the correlation of the importance of runnability versus the importance of price across firms is -19.7%. Thus firms who care about runnability care less about price and vice versa.

5.2.1. Expected Signs

The percent of digital printers in the company is assumed to be positively correlated with the importance of runnability. Evans and LeMaire (2005) write that "with new technological developments in electrophotographic printing, more stringent demands are being placed on paper performance". Paper performance incorporates the functional areas runnability, printability and fitness for use. Thus, in general, digital printing requires paper with superior runnability and the expected sign for *Dig_printer_perc* as well as *DAM* and *Digital_asset_train* is positive.

[11] See Evans and LeMaire (2005) Page 9

Special attention is placed on runnability in Variable Data Printing. Evans and LeMaire (2005) state that downtime is a "particular issue in Variable Data Printing where the loss of a single sheet can disrupt the integrity of the print run." The inclusion of a dummy variable *VDP* should pick up this effect. The predicted sign for VDP is positive.

Downtime caused by poor paper runnability will be costly across all printing jobs, but might affect firms to a different degree. For example, certain printing jobs might involve a more intensive press usage or may incorporate different late fees.

Specific digital presses utilized, could impact the runnability requirements as some printers might be especially sensitive to paper properties like stiffness. For instance, the HP Indigo printer is known to produce high quality prints at a relatively high cost.

If the customer alone decides which paper to buy, then the quality/appearance of the paper is of central interest and runnability is less likely to be a concern. Therefore the expected sign for *Alone_customer* is negative.

5.2.2. Estimation Results

Since almost every firm ranked the importance of runnability as critically or at least somewhat important (that is, either category 5 or 4) a binary Logit was estimated. Companies that ranked runnability lower than somewhat important were included in category 4. [Table 6] shows the resulting distribution of companies as well as the final model, found by eliminating insignificant variables. The likelihood ratio test is rejected with a p-value of 0.0020, indicating a strong model fit.

Revenue_growth is the only variable from the set of demographic variables that turns out to be fairly significant (p-value 0.18). Although the p-value signals a rather weak significance, the implication is quite interesting. The faster a firm's revenue grows the more the firm emphasizes runnability. The introduction identified two problems resulting from poor runnability; time and material costs. While the material cost will be similar for all firms the time cost will be substantially higher for successful firms excelling high growth.

Table 6: Estimation results for the Importance of Runnability regression

Binary Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept	0.032	1.499	0.9830	
Revenue_growth	0.519	0.391	0.1847	1.680
PJ_marketing	0.490	0.379	0.1966	1.632
PJ_book	-0.562	0.301	0.0618	0.570
Dig_printer_perc	0.022	1.094	0.0455	1.022
Dig_printer_na	0.224	1.373	0.8701	1.252
Digital_asset_train	1.528	0.703	0.0296	4.611
Portfolio	-0.735	0.292	0.0120	0.480
Alone_customer	-1.598	0.778	0.0399	0.202
Log-likelihood at mean			-53.11	
Log-likelihood at convergence			-40.95	
Frequency in category				
Runnability_imp=5	69			
Runnability_imp=4	24			

Companies printing marketing materials are more likely to emphasize runnability and care less about the price of the paper. This is in line with Evans and LeMaire (2005) who report that there is a "trend towards short run, variable data electrophotographic printing for targeted marketing applications" [requiring] "robust paper runnability". The positive coefficient of *PJ_marketing* can be assumed to be driven by the use of Variable Data Printing. This argument is only valid since the dummy *VDP* was not included in the regression. Note also that the variable is significant at an 80% confidence level and was primarily included for the purpose of contrasting the result to the importance of price.

The variable *VDP* did not turn out to be statistically significant in the overall model. Even when run independent, the variable remains statistically insignificant (p-value 0.37). This result stands in contrast to Evans and LeMaire (2005) who predict that firms who do Variable Data Printing will require higher runnability. However, the sign is positive as expected with a coefficient of 0.4235. The insignificance of the variable might be caused by the low number of observations.

As expected, the sign for *Dig_printer_perc* is positive. The more a firm is involved in digital printing the more it emphasizes the runnability of paper. Similarly, *Digital_asset_train* shows a positive sign. Evans and LeMaire (2005) argue: "Compared with many offset requirements, sheet properties for digital printing must be more stringently controlled … in order to meet the jam-free requirements of complex high-speed paper paths." The coefficient on *Dig_printer_perc* is high, indicating the central importance of the variable. Consequently, a firm that has progressed further towards a digital printing firm is more likely to emphasize runnability in the paper purchase decision.

Portfolio has a negative coefficient indicating that the larger the purchasing portfolio of a firm the less the firm cares about runnability. One interpretation is that these companies care more about price than about runnability. A correlation between *Price_imp* and *Portfolio* of 7.4% supports this view.

The variable *Alone_customer* is significant at the 95% confidence level and carries the predicted sign. This supports the assertion that if the printing company delegates the paper purchase decision to the customer, the emphasis on runnability will be lower. Most of the companies are unable to pass on higher costs to customers in its entirety. Thus, the burden of higher costs is shared between the two parties. Therefore it can be assumed that a customer's main concern is the quality of the end product and not production cost.

5.2.3. Effects on predicted probability

This section explores how changes to independent variables affect the probability of ranking runnability as high (category 5) or low (category 4). The results are reported in [Table 7].

Revenue_growth was set to a value of 2, representing no growth. *PJ_marketing* and *Portfolio* were also set to a value of 2. *PJ_book* was set to a value of 1. *Dig_printer_perc*, the only continuous variable, was set to its mean with a value of 36. The dummy variable *Dig_printer_na*, *Digital_asset_train* and *Alone_customer* were set to 0.

Table 7: Effects on *Runnability_imp*

Variable	Discrete	Marginal	Quasi-Elasticity
Revenue_growth	0.091		
PJ_marketing	0.086		
PJ_book	-0.124		
Dig_printer_perc		0.004	0.190
Dig_printer_na	0.042		
Digital_asset_train	0.199		
Portfolio	-0.166		
Alone_customer	-0.377		

A firm exhibiting some growth after a period of stagnation is more likely to rank runnability high by 0.09. Similarly, a firm that prints marketing materials very frequently as opposed to somewhat frequently has an increased likelihood of emphasizing runnability of about 0.09. Increased involvement in book printing decreases the estimated probability by 0.124. A firm that trains its employees in Digital Asset Management has an increased probability of ranking runnability as high by 0.19. Increasing the firm's portfolio size from less than six to a size of six to ten firms decreases the probability of

ranking runnability high by 0.17. If the customer alone decides on which paper to purchase then the printing firm's probability of ranking runnability high decreases by 0.37.

The effect of the variable *Dig_printer_perc* is of special interest in the regression as it quantitatively measures how the use of digital printers in a company changes the emphasis on runnability in the paper selection. The quasi elasticity has a value of 0.19 whereas the marginal effect computed is 0.004. [Figure 4] shows how an increasing percentage of digital printers in a firm affects the likelihood of that firm highly emphasizing runnability. The likelihood increases from initially 0.5 to about 0.9 as *Dig_printer_perc* varies from 0 to 100. It is also interesting to notice that the impact decreases as the variable reaches higher levels. A diminishing marginal effect can be observed.

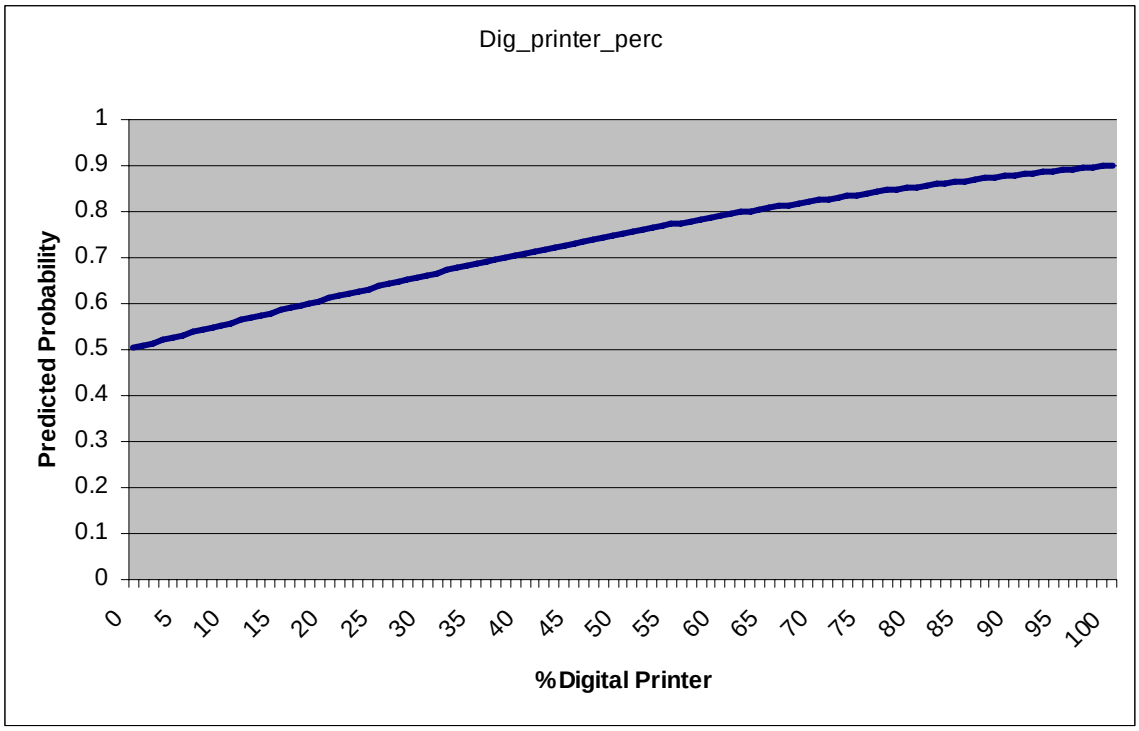

Figure 4: Pred. prob. of *Runnability_imp*=5 for levels of *Dig_printer_perc*

5.3. Results for other Importance Factors

Apart from the importance of price and the importance of runnability, other importance factors were considered in the survey. [12] In order to complete the picture the results will be discussed briefly in the following.

The importance of quality receives the second highest importance by the respondents, right after runnability, thus deserving considerable attention. In order to interpret the empirical results it is important to remember the following common business strategies.

Porter (1979) identifies five forces a company faces in a market. One year later Porter (1980) describes two main generic competition strategies to generate a defendable position against the five forces. One is Cost Leadership and the other is Differentiation Strategy. Porter's work has tremendous influence on practiced business strategy and it can be expected that a large number of firms in the sample follow a similar strategy. Remembering that the paper purchase price is the input price for the firm, one can expect a company pursuing Cost Leadership to purchase cheap paper (i.e. care much about price) and a company that follows a Differentiation Strategy to purchase high quality paper (i.e. care much about quality).

Equipped with this idea, the correlation between the importance of price and quality was computed and the importance of quality was regressed on the set of explanatory variables in [Table 1]. The correlation between the two variables over the 93 firms is -6.2% supporting the above view that firms which care about price tend to care less about runnability. The estimation of the model resulted in only one significant coefficient and thus little room for comparison between the importance of price and quality. The only significant coefficient in the regression is the dummy variable *PJ_marketing*. The estimated coefficient is 0.6648. The model for price importance yielded a coefficient of -0.5555. This means firms printing marketing materials

[12] See [Figure 1]

emphasize quality as opposed to price and suggests that they are more likely to follow a Differentiation Strategy.

The fact that only one variable turned out to be significant in the importance of quality model restricts the information we can obtain from it. However, it was noticed that the importance of appearance is highly correlated with the importance of quality (49.94%). Appearance characteristics of the paper include weight, size and finish. It can be argued that appearance characteristics are part of the quality of the paper. For example, it can be considered part of the quality of the paper not to exceed a certain weight while maintaining good toner/ink adhesion, uniformity etc.

The model for the importance of appearance yielded two highly significant coefficients as well as one coefficient significant at the 88% confidence level. Just as in the regression of the importance of quality, *PJ_marketing* has a positive coefficient (0.6643). Interestingly, the variable *DAM* turns out to be significant in the regression of the importance of appearance too with a coefficient of 1.0298. Therefore, companies that are involved in Digital Asset Management emphasize the appearance/quality of the paper and the model provides evidence that companies doing Digital Asset Management are more likely to belong to the set of companies that follow a Differentiation Strategy as they care more about the appearance/quality of the paper.[13]

Models for the remaining questions on the importance factors were estimated. Although several variables turned out to be significant, the results do not provide substantial further insights into the purchasing behavior of digital printing firms. Thus, a detailed discussion will not be provided. However, it is striking that in both the importance of product range as well as the importance of availability of paper grade, the variable *Dig_printer_perc* turns out to be significant. This is a further indication that the degree, to which a firm is involved in digital printing, plays a crucial role in its paper purchase behavior and can be considered one of the most important results of this analysis.

[13] The third variable in the regression is *None* with a coefficient of 0.8301 and a p value of 0.1204.

CHAPTER 6: Summary Part I

The statistical analysis of two aspects of the paper purchase decision identified some interesting results about the paper purchasing behavior of digital printing firms. Smaller, slow growing firms tend to put a high weight on the paper price whereas fast growing firms primarily focus on the runnability of paper. One reason for this result is that successful firms have a larger opportunity cost of foregone production.

Firms that are printing marketing materials care mostly about runnability. One possible reason is that many are involved in Variable Data Printing which puts higher requirements on runnability, as the loss of one sheet can disrupt the whole print process.

A printing company that makes the paper purchase decision together with its customers is less likely to put high emphasis on the price of paper. Evidence was also found that companies able to pass to the customer, a high percentage of cost increases in paper price care less about the price. Thus, companies who collaborate on the paper purchase decision with their customers are able to pass on their cost increases.

The percentage of digital printers in a firm was central in explaining numerous importance factors. In particular the importance of runnability is driven by the involvement in digital printing. The underlying reason is that runnability requirements for paper used in digital printing are higher.

If a company delegates the paper purchase decision to the customer the importance of runnability is lower. Customers will put a higher weight on other criteria such as the quality and appearance characteristics of paper.

Finally, the analysis of the importance of quality/appearance revealed that a firm's involvement in the advanced technology of Digital Asset Management signals the focus on high quality paper. Assuming that firms using high quality paper do so in order to produce superior quality products, it is inferred that these firms are likely to follow a Differentiation Strategy.

PART II: THE CHOICE OF COATED VERSUS UNCOATED PAPER

CHAPTER 7: Introduction Part II

The importance factors were an indirect way of determining which paper a firm is likely to purchase given its characteristics. A different approach is to directly look at what paper a firm actually uses and then make a connection to the firm's characteristics. In particular this part of the analysis seeks to understand the choice between coated and uncoated paper.

CHAPTER 8: Data and Methodology

The data set includes information on the paper grades used in each firm. Grade descriptions, such as "coated gloss", were used in order to avoid resemblance to brand names. For a total of 14 paper grades, firms reported the frequency of use on a scale from 1 to 4.[14] Respondents identified the grade used most frequently in a separate question. Both questions could potentially be used to analyze the paper grade selection of firms.

Since a choice between 14 different paper grades was impossible to model, given the number of observations, the paper grades were grouped in *Coated, Uncoated* and *Other*.[15] Coated paper, in general, is more expensive and of higher quality than uncoated paper. Given that digital printing is used for high quality printing, it is expected that companies focused on digital printing will use coated paper.

The paper grade *Other* is comprised of recycled paper, synthetic grades, textured and tinted and colored paper. Paper grades in the category *Other* can be coated or uncoated. Therefore the three categories are not mutually exclusive and a model describing the choice among the three groups is not meaningful.

Making use of both questions individually two approaches were utilized to analyze the paper grade selection.

[14] For a detailed discussion of the survey results see Evans and LeMaire (2005)

[15] Even if enough observations were there the results would be hard to interpret.

CHAPTER 9: Estimation Results

9.1. Separate models of firm's paper choice

First, two dummies named *Coated* and *Uncoated* were created and assigned a value of 1 if a firm indicates very frequent use of one coated or uncoated paper grade respectively. A binary Logit model was estimated to model the probability of using coated paper. The results reported in [Table 8] indicate a strong model fit with a p-value for the likelihood ratio test of 0.0020.

Table 8: Binary Logit regression for Coated vs. not Coated

Binary Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept	1.258	0.955	0.1876	
Revenue	-0.462	0.231	0.0449	0.630
PJ_manuals	-0.771	0.414	0.0626	0.463
PJ_catalogs	1.325	0.477	0.0055	3.761
PJ_book	-0.460	0.285	0.1056	0.631
DAM	1.656	0.765	0.0305	5.238
VDP	1.067	0.577	0.0642	2.907
None	-1.344	0.648	0.0381	0.261
Log-likelihood at mean		-57.71		
Log-likelihood at convergence		-46.42		
Frequency in category				
Coated=1	64			
Coated=0	29			

The smaller the firm's revenue, the higher the chances are that the firm uses coated paper very frequently. Additionally, firms printing catalogs tend to use coated

paper. Both results stand in contrast to the estimation of the importance of price where smaller firms and firms printing catalogs were found to care more about the price. One can argue that although small firms printing catalogs care more about the price, there are reasons that require them to use coated paper despite it being more expensive in general,. For instance, catalogs are usually used to advertise certain products. In order to appeal to customers the shinier coated paper is typically employed.

In contrast, the coefficients for the variables *PJ_manuals* and *PJ_catalogs* are both negative and indicate that higher involvement in those businesses reduces the chance of firms using coated paper. Books and manuals convey knowledge, usually are not advertising items and contain a larger number of pages compared to catalogs. Therefore, the use of uncoated paper is very common.

The most striking result in the regression is that *DAM* and *VDP* turn out to be significant and both show a positive coefficient. This result is in line with the expectation that firms using more advanced techniques tend to use higher quality paper.

If a firm faces some sort of restrictions on the paper selection imposed by the technical requirements of the presses, that is the variable *None* has a value of zero, it is more likely to use coated paper. A possible explanation is that presses which impose restrictions require higher quality paper in general to function well.

The use of uncoated paper was modeled in a similar fashion and reported in [Table 9]. It shall be sufficient to report that the variable *HP_indigo* turns out to be highly significant with a strong negative sign indicating that firms which use *HP_indigo* are less likely to use uncoated paper. As the HP Indigo produces high quality prints at relatively high costs printing firms generally avoid the usage of low quality uncoated paper.

Finally, the variable *Weight* is significant with a strong positive coefficient. If the printing presses of a firm restrict the paper weight, then the firm is more likely to use uncoated paper and less likely to use coated paper, which makes sense because coated paper tends to be heavier.

Table 9: Binary Logit regression for Uncoated vs. not Uncoated

Binary Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept	0.931	0.558	0.0955	
Revenue	-0.595	0.220	0.0069	0.552
PJ_trans	1.100	0.342	0.0013	3.005
HP_indigo	-1.388	0.661	0.0357	0.250
weight	1.592	0.767	0.0379	4.911
Log-likelihood at mean			-56.03	
Log-likelihood at convergence			-38.10	
Frequency in category				
Uncoated=1	66			
Uncoated=0	27			

The weakness of the above analysis is that there are two models to describe the choice between coated and uncoated paper of the printing firms. The problem arises as a result of the way the first question is posed. It is possible that a firm uses one grade of coated and one grade of uncoated paper very frequently. In that case *Coated* and *Uncoated* are not mutually exclusive and a binary Logit cannot be estimated.

9.2. Single model of firm's paper choice

To overcome this problem, the second question related to the choice of paper grade was used. The companies were forced to state one paper grade out of the 14 that they used most frequently. The dependent variable *Grade* is assigned a value of 2 if the firm uses coated paper and a value of 1 if the firm uses uncoated paper most frequently. The firms that cite a paper grade in the category *Other* as the paper grade used most frequently are eliminated from the data set. Then a binary Logit with coated vs. uncoated is estimated.

The results are listed in [Table 10]. The model fit is not very strong. However, it is interesting to observe that the signs of the coefficients are in line with the analysis of C*oated* and *Uncoated*.

Table 10: Binary Logit regression for Coated vs. Uncoated

Binary Logit Regression				
	Coef.	Std. Error	P-value	Odd Ratios
Intercept	-0.027	0.953	0.9773	
PJ_manuals	-0.530	0.395	0.1788	0.624
PJ_catalogs	0.367	0.392	0.3490	1.462
PJ_trans	-0.445	0.259	0.0856	0.655
PJ_book	-0.201	0.262	0.4449	0.810
HP_indigo	0.516	0.709	0.4669	1.574
DAM	-0.471	0.622	0.4488	0.623
VDP	1.506	0.609	0.0134	4.310
Portfolio	0.416	0.253	0.0991	1.492
Cut	-0.284	0.726	0.6956	0.888
Weight	0.328	0.537	0.5405	0.624
Log-likelihood at mean		-57.84		
Log-likelihood at convergence		- 50.89		
Frequency in category				
Grade=1 (Coated)	46			
Grade=0 (Uncoated)	38			

The variable *HP_indigo* has a positive sign, supporting the above view that if a firm uses an HP Indigo printer it is more likely to use coated paper compared to uncoated paper. While *VDP* is highly significant with the sign expected from the above analysis, *DAM* shows the opposite sign and is not significant. Thus, *DAM* has an important impact on determining whether a firm chooses coated paper at all but does not influence the choice between coated versus uncoated paper very much.

Due to the insignificance of the majority of independent variables, the regression is mainly presented to support the results for the separate regressions but will not be subject to further analysis.

9.3. Effects on predicted probability

Effects of changes in the independent variables on the predicted probabilities for the two separate models are presented in [Table 11]. All dummies (*DAM*, *VDP*, *HP_indigo*, *Weight* and *None*) are initially set to 0. *Revenue* and *PJ_manuals* are assigned a value of 2. This implies a revenue level of $3 million to $5 million assumes that manuals are a minor part of the business. *PJ_catalogs*, *PJ_book* and *PJ_trans* are assigned a value of 1 assuming that catalogs, books and transactional forms are printed rarely.

Table 11: Effects on pred. prob. for separate models

Variable	Discrete Change Coated	Discrete Change Uncoated
Revenue	-0.115	-0.109
PJ_manuals	-0.187	
PJ_catalogs	0.279	
PJ_trans		0.119
PJ_book	-0.114	
DAM	0.325	
VDP	0.236	
HP_indigo		-0.296
Weight		0.146
None	-0.303	

According to the separate models, increasing revenue above a level of $5 million reduces the chance of using one kind of both coated and uncoated paper very frequently by about 0.11. When interpreting this result it is important to remember that decreasing probability of using one kind of coated paper grade very frequently does not necessarily imply that the overall usage of coated paper goes down. Since paper is either coated or uncoated a negative effect of Revenue in both regressions implies that more paper grades

will be used at least rarely or somewhat frequently. Therefore the result implies that as revenue increases a larger number of paper grades are used less frequently.

As a firm introduces Digital Asset Management and Variable Data Printing the likelihood of using one kind of coated paper very often increases by 0.32 and 0.23 respectively. The strong effect of both variables supports the view that more advanced firms will use coated paper for their printing jobs.

Finally, the variables *HP_indigo* and *None* show strong effects on the predicted probability. If a firm uses an HP Indigo press it is less likely to use uncoated paper very often by around 0.3. If no restrictions on the choice of paper exist, the likelihood of using coated paper is reduced by around 0.3. A potential explanation cited above is that if no restrictions are posed by the printing press, the use of lower quality, uncoated paper is feasible.

CHAPTER 10: Summary Part II

In the second part of the analysis the use of certain paper grades were explained by the firms' characteristics. In particular the decision between coated and uncoated paper was analyzed.

In order to model selection of coated and uncoated paper, two approaches motivated by the structure of the survey questions, were undertaken.

The first approach encompassed two separate models, one modeling the selection of coated paper very frequently, the other modeling the selection of uncoated paper very frequently. Most notable is that the model for coated paper yields interesting results.

The second approach makes use of a survey question forcing respondents to name only one paper grade they use most often. The dependent variable was assigned according to whether that paper grade is coated or uncoated. This approach yielded mostly insignificant variables so that the results were mainly used to contrast the estimations of the two separate models.

The analysis showed that firms performing sophisticated techniques, such as Digital Asset Management or Variable Data Printing, are more likely to use coated paper. Firms using more advanced technologies require higher quality paper and coated paper is generally of higher quality. The central importance of Variable Data Printing is supported by the high significance of *VDP* in the regression of coated versus uncoated.

The coefficient of *Revenue* is negative in both the regression for coated paper and the regression for uncoated paper. This result can be explained by the fact that the dependent variables *Coated* and *Uncoated* reflect that one coated or uncoated paper grade is used very frequently. Thus, if both coefficients are negative it can be inferred that a larger number of paper grades is used with a relatively low frequency.

Firms printing catalogs have a substantially higher probability of using coated paper. Coated paper is used to appeal to individuals and promote, for example, a certain product or institution. If a firm produces manuals or books it is less likely to use coated paper, since both of them are usually printed on the cheaper uncoated paper.

Lastly, firms with restriction on the paper press are more likely to use coated paper as some of the restrictions might require the use of high quality paper. However, if a paper press has a weight limitation, very frequently use of uncoated paper is necessary since coated paper is generally heavier than uncoated paper.

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